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THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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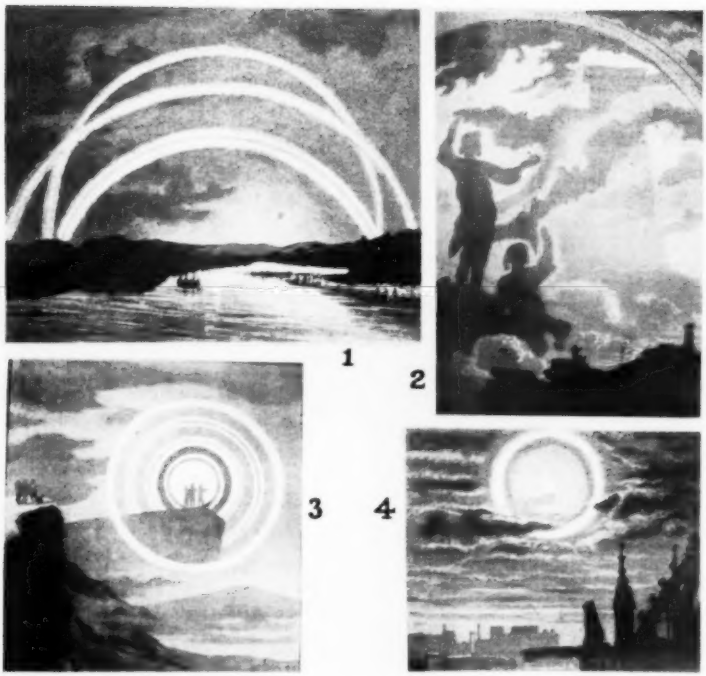
PLATE I

PHOTOGRAPH OF THE PRIMARY RAINBOW

Taken by E. E. Barnard, at the Yerkes Observatory, 1919, Aug. 16.
(Note that the space within the bow is brighter than that without)

Journal of the Royal Astronomical Society of Canada

PLATE II



SPECIAL FORMS OF RAINBOWS AND FOGBOWS
(From Flanemarion's *L'Atmosphere*)

1. Irregular rainbow formed by the reflection of solar rays from a smooth water surface. 2. Shadow Mirage, or Brocken Spectre. 3. Aureole, or Anti-Corona. 4. Corona, around the sun or the moon.

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RAINBOWS, FOGBOWS AND THEIR ASSOCIATED PHENOMENA

BY A. F. HUNTER

When a drop of rain is falling through the air it takes the form of a smooth ball or perfect sphere. Although it falls too fast for one to examine its shape, it is known from other facts that it is perfectly spherical. Thus, it may become frozen as hail, and its shape preserved for examination; or, in that other form of the frozen, but less compact, raindrop known as sleet, we can also see the round form.

The manufacturers of small, lead gunshot have taken advantage of the law that all liquids globulate when unsupported, and erect shot towers for the manufacture of small shot; at the top of the towers melted lead is allowed to drip through small openings. It cools while falling, and by the time it reaches the ground it has formed beautifully perfect, and solid, little spheres.

Indeed, it would be possible to show the application of this law to wider fields than the liquids we are acquainted with, as the millions of suns, moons, stars, and planets are all spheres, so far as we can see. There is no need to prove, for the benefit of one who has watched the ways of Nature, that the earth is a sphere, as he

will know this from the sum of his experience. It will be sufficient, however, for our present purpose to remember that the countless millions of raindrops, and the droplets in clouds, fogs, etc., all take the spherical form. And these raindrops and droplets make no exception to other rules, but, like the stars organized into spiral nebulae, they are chiefly arranged in great spirals called "cyclones," —a feature, however, which it is not in our present programme to examine.

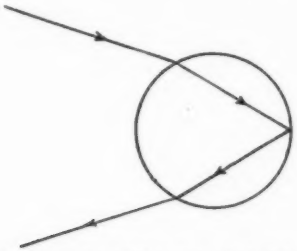
The present enquiry is to examine the action of light upon groups of these small spheres, and to investigate the formation of bows and rings by that action. The raindrops and droplets are among the commonest things in Nature,—as abundant as the proverbial sands of the seashore,—and yet the study of the action of light upon them seems to be much neglected, if I may judge from the condition of the encyclopaedias in their treatment of the various terms relating to the subject.

The best plan to pursue, perhaps, will be to give a list of the different kinds of bows seen in Nature, and a description of each so that it can always be recognized. Mathematical treatment is useful to give accuracy to any examination of these phenomena, but does not contribute materially to the development of the subject as there is nothing further in the conclusions than is contained in the premises. The growth of the science depends upon good observations, and so it will be more suitable in this general treatment to omit the mathematical method and confine ourselves to a list or catalogue of the different forms.

In addition to presenting the ordinary phenomena of refraction and reflection of light, the action of light upon the small spheres of water in the air results in two phenomena standing out more conspicuously than others, viz., prismatic dispersion of the light, and magnifying power.

THE RAINBOW. Authorities differ from each other in the representation of what takes place in the formation of the ordinary rainbow, some of them giving diagrams that exhibit a focus formed within the water drop, a slight distance in advance of the back of the drop. When dispersion takes place as the sunbeam enters the drop, and the dispersed beams are projected against the back of the drop as a screen, the original white sunlight is not left in

existence to form an image by reflection in front of the mirror-like back of the drop, but the dispersed rays are actually reflected from the back of the drop. (See accompanying figure).



Path of a ray of light through a raindrop in producing the primary rainbow

What we see, therefore, reflected from the back of the drop is really a magnified image of the sun in coloured lights, or, because our position is a fixed one in relation to the falling drops, it is only a part of an image that we see in each drop. This is further magnified on its emergence from the drop which again acts as a lens. The sun's magnified partial images, that we see, fill the whole field of view at a uniformly constant angle with the observer's eye, and give us that pleasing phenomenon we know by the name of the rainbow.

When two reflections take place within the drop, the sunbeams perform a sort of "loop-the-loop" or somersault, and give the secondary bow with colours reversed. There is a dark zone between the primary (radius about 42°) and the secondary (radius about 54°) bows, having a width of about twelve degrees between the red edges which immediately bound the zone. The breadth of the bow itself is a degree or more, being the sun's image doubly or trebly magnified by the raindrops by multiple magnification, and the smaller the drops the wider is the rainbow they produce. In the Isle of Lewis, Scotland, where the rain was a drizzle or Scotch mist, I observed a rainbow much broader than elsewhere, about twice that of the ordinary rainbow. And high waterfalls (of a thousand feet or more) where the rivers or streams are dissipated in spray by the greatness of their descent, such as those

which occur in the Hawaiian Islands, produce in the sunshine numerous and very beautiful rainbows.

When the drops are nearly all of one size the bows become particularly bright, and supernumerary bows are then formed by diffraction or interference. These appear close to the violet edges or most refrangible sides of both the primary and the secondary bow. Prof. Tyndall produced extensive series of these supernumerary bows by artificial means, and counted as many as eight within the primary bow and five outside of the secondary bow. (See the chapter on "The Rainbow and its Congeners" in his "New Fragments.")

ECCENTRIC RAINBOWS. When a lake or large pond with a smooth surface reflects an image of the sun, another rainbow with diminished intensity is formed by the reflected rays. This intrusive bow crosses the ordinary primary and secondary bows, being eccentric in comparison with them (see Plate II, Fig. 1). A part of an eccentric bow of this kind was observed by the late Dr. David Boyle in August, 1896, and he communicated some particulars of the phenomenon to this Society. (See *Transactions* for 1896). This unusual rainbow was seen over Rice Lake, Ont., for a brief period of time, the lake producing the reflection necessary for its formation.

FOGBOWS

All that I have said of raindrops and the action of light upon them is equally true of the small droplets which form fogs, mists and clouds. The droplets, when massed thickly together, produce white colour by the mixture of all the primary colours, and thus clouds present a white colour in sunlight, except when so thick as to make a shade. But when thinly spread in the atmosphere, the droplets produce a numerous series of bows and colour phenomena. The only difference between raindrops and droplets is in their sizes, which in fogs and clouds are so small that a hundred or more are needed to produce a single drop of rain. The average diameter of the droplet is the one one-hundredth part of a millimetre. This difference in size is one of fundamental importance, and it introduces us to many new forms and phenomena.

The business of rain-making, about which we read much in the newspapers in the early part of the past summer (1921), consists of nothing more than compelling the droplets which may be in the air to coalesce into larger drops and come down as rain from their high positions. A gun fired off beside a pond with a smooth surface, when a mist hangs over it, produces a smart shower of drops on the surface of the pond. The disturbance produced by the sound apparently is sufficient to make a number of the droplets coalesce and fall. In the same manner, by sending up explosives in the form of rockets, etc., to the clouds, they may sometimes give rain, though only in very small quantities.

It is unlikely that much success will be attained by this bombardment of the clouds, beyond a certain degree, until the problem is attacked through electrical methods, as the droplets, which are pertinaciously unsocial by reason of being similarly electrified, stand apart from each other persistently, and from the earth,—similarly electrified bodies always repelling each other in accordance with the law of electric repulsion.

The danger to human life, however, from the use of electrical methods in connection with rainmaking, would be almost insurmountable. But a gleam of hope arises from the recent perfection of automatic machinery to be operated at a distance by wireless, and therefore, without the need of human operators being present. Vertical flight without the use of gas is also claimed as a recent invention. The use of balloons, etc., attended by men for the purpose of the condensation of clouds into rain, could then be dispensed with, as a result of the two inventions, and the problem's solution would become possible without endangering human lives from electric effects. Both inventions, however, are claimed as military achievements, intended for the ulterior destruction of life, whereas the proposed application mentioned above to rainmaking is to save life, so some time may elapse before the inventions are disclosed or turned to rational uses. By any method, however, the amount of rain produced would be comparatively slight on account of the great power required. An ordinary shower, such as Nature appears to supply with ease, would demand an expenditure of millions of horse-power.

A century and a half ago, Horace Benedict de Saussure put

forward a theory that in fogs, clouds, etc., the floating droplets of water are vesicles, i.e., small hollow spheres. De Saussure held for twenty-five years (1762-87) the chair of philosophy in the College of Geneva, and was regarded as a good authority in physical science. The weight of his authority gave the erroneous theory a wide acceptance, and it is still in vogue on the continent of Europe. Auguste Bravais, a French scientist who did much to advance our knowledge of halos or the figures and bows of light formed by snow crystals, followed de Saussure in holding this theory of droplets. Prof. John Tyndall sought for these vesicles but could not find them, ("Hours of Exercise in the Alps," p. 175), and he had no difficulty in disproving their existence. The proof that the droplets are not hollow but are small solid drops like miniature raindrops lies in their reaction to light, which in every respect is precisely the same as for raindrops, with the only difference that they are much smaller. British men of science, generally, have refused to accept the vesicle theory, although there was some excuse for the error by other European scientists, as the behaviour of droplets in floating and remaining suspended for indefinite periods in the air gives them the appearance of being small balloons. But the electrostatic action to which they are subject fully explains all these peculiarities of their behaviour. These general considerations in regard to the droplets will enable us to examine more lucidly the various classes of bows, to which we now proceed.

THE HORIZONTAL BOW. Standing on one of the wharves at Barrie at 8 o'clock on the morning of September 4, 1911, I observed a flat bow with spectrum colours spread out before me on the surface of the water, and was puzzled to understand the cause of it, as no rain was falling and the sun was shining, although there was much haze in the atmosphere. The surface of the bay was as smooth as a mirror; not a ripple was to be seen. There was a slight mist or steam rising from the surface of the water, and this remained visible for a few feet above it, while the air still higher was more hazy than usual, but this did not interfere much with the sunshine or with vision, nor did it prevent me from seeing objects on the opposite shore reflected from the surface of the water. Although the spectrum colours of the bow were not brilliant, they were distinct, having a wider dispersion than in

the ordinary rainbow, being like a corona or ordinary fogbow with more perfect colours than usual. Although unable to understand the phenomenon at the time, I made a note of the hour and the circumstances. The altitude of the sun on September 4, in the latitude of Barrie, is about 24° at 8 a.m.

Slowly I began to realize that I had witnessed one of those rare phenomena called the horizontal bow, and at a later time I came upon an article by a Japanese writer (S. Fujiwhara) reprinted in the U.S. *Monthly Weather Review* for July, 1914, in which he points out that one of the essential conditions for the production of these horizontal fogbows is perfect stillness of the surface of the water so that the rays of the sun may be reflected upward into the adjacent layer of thin fog or mist; and he also finds that an ellipse, hyperbola or parabola is produced according to the conditions of angle and position of the observer. With the conditions under which I saw the horizontal bow on that occasion, it would appear to have been a parabola.

Steam rising from the smooth surface of a dish of warm water from which the sun's rays are reflected upward into the steam also produces iridescent or rainbow colours, sometimes very vivid when seen at a distance of a few feet. And I have observed likewise, the spectrum colours from steam rising off a small pool of water formed by snow melting in a hot sun in early springtime. In these cases when the reflected and dispersed sunbeams are directed toward the observer, the form of the bow appears to be the hyperbola, both of whose branches may sometimes be seen by a slight shift of the observer's position.

James Clerk Maxwell described a horizontal bow which he saw at Cambridge, England, in 1870. (Edinburgh Roy. Soc. *Proc.*, Vol. 7., also "Scientific Papers," II, p. 160).

THE CORONA. The coloured circle around the sun or the moon, called the corona, is a very common phenomenon, especially since the introduction of the electric light into general use about thirty years ago, as it may nowadays be seen around every bright arc light in the open air, except in the dryest weather. The red edge is at the outside, and is about 6° from the orb. The corona appears to be caused by the light passing through the small droplets of fog or cloud, which are always present in the air. Dispersion

of light into the primary colours takes place, these colours are thrown upon the transparent backs of the droplets as upon a screen, and we thus see the colours on the droplets themselves as in the rainbow, directly instead of by reflection. The altered position of the observer alters the angular position of the corona in comparison with that of the rainbow. (See Plate II, Fig. 4).

Thomas Young, the projector of the undulatory theory of light, put forward the theory that the coloured circles called coronas are the result of diffraction or interference. This view has been repeated in a somewhat garbled form by many encyclopaedia writers who have insufficient acquaintance with the subject to narrate clearly the right view of the phenomenon, but do not hesitate to appropriate a wrong one. As in the case of the supernumeraries of the rainbow, the circles beyond the first one may be due to interference, but in regard to the first one, as in the rainbow so in the corona, the primaries must be formed by refractive dispersion and the subsequent ones by interference, which Young probably meant. All interference starts with a refraction or a reflection, as in Newton's rings with a refraction or in opaque diffraction gratings with a reflection. There must be refractions through the droplets, or reflections from their interior surfaces, before the interference can begin, and so both operations take a share. Overlapping of colours may also be frequent whether due either to refractions or to interference.

The corona of an electric light becomes visible at a certain effective distance from the light. Occasionally, as one approaches the light, a prismatic ring appears and its diameter diminishes on nearer approach; on still nearer approach, another coronal ring, closer to the light than the former one, sometimes comes into view. The latest available edition of "Larousse," the standard encyclopaedia of the French, describes the corona (couronne) as being produced by the undulations of light-rays which, in their passage among the "vesicles," produce interference. Correct descriptions of the corona and the order of its colours are as old as the time of Newton, or older, as he described correctly a double one around the moon. (See his "Optics," Bk. II). It is unfortunate that the term "corona," besides its use in this branch of the optics of the air, is also used in solar physics and also in con-

nection with the aurora, in all three of which connections it has entirely different meanings.

THE AUREOLE, OR ANTI-CORONA. Shadows made by the sun, moon or any bright light against a fog often show coloured rings. These surround a brighter zone of light, called the aureole, around the shadow, and they have the red edge of the spectrum inside,—the opposite of the corona. As many as five such concentric prismatic rings have been seen extending to twelve degrees. (See Plate II, Fig. 3).

From the top of the Scuir of Eigg, in the Scottish Hebrides, Hugh Miller observed anti-coronas around the shadows of himself and companion, and described what he saw in "The Cruise of the Betsey," Chap. 3, as follows:—

"The sun had declined half-way down the western sky, and for many yards the shadow of the gigantic Scuir lay dark beneath us along the descending slope . . . . . Far below, perched on the apex of the shadow, and half-lost in the line of the penumbra, we could see two indistinct specks of black, with a dim halo around each,—specks that elongated as we arose, and contracted as we sat, and went gliding along the line as we walked."

Under certain conditions of the atmosphere, I have observed the aureole, without colours, around my own shadow against dew-covered grass or on the pavement, and if there had been a dark background, dimly coloured rings would doubtless have been visible. The penumbra of one's shadow is a factor in the phenomenon, as Hugh Miller did not fail to observe in the above-mentioned instance. Near the head, i.e., the most remote part of the shadow, the penumbra is necessarily broader than at the feet, and this sometimes becomes brighter than the surrounding sunshine, the aureole being the result.

THE WHITE BOW. The White bow, or the so-called Ulloa's circle, has a radius of 33° 30′, according to Prof. Tyndall, but it seems to be variable and an example of one at 22° will shortly be cited. It is concentric with the anti-coronal rings and with the primary rainbow, and has been accounted for in various ways. Thomas Young explained the white bow as a result of the overlapping of the "supernumeraries," which it doubtless results from in some instances, very small drops being necessary for

their formation, but this view still lacks confirmation by experiment.

Another cause of the white bow is by reflection of light from the exterior surfaces. When the sun shines brightly upon thick volumes of steam, the reflected light is strongest at the above-mentioned angle measured by Prof. Tyndall, and thus it would appear that the white bow may be due to external reflections of the sun's image off the small droplets. Theoretically, there is only one position at which an image of the sun, for example, can be reflected with maximum brightness from the external surface of a drop or a droplet of water, and when thus reflected externally the image is very small,—too small to be noticeable in a rain shower, notwithstanding the numbers of the raindrops. But if the droplets are very numerous and thickly massed together, as in a fog, the reflections may be strong enough to make an impression on the eye and thus may become visible. As the angular position of the white bow, in this case, differs from the position of the primary bow by the amount of deviation of light as observed in the width of the corona, it is obvious that reflection from the outer surfaces of the droplets is the cause of the white bow, in this class of cases, at least. If it were due to the overlapping of the supernumeraries, the white bow would always have coloured margins, but in these cases the margins are uncoloured, and hence it must be due to external reflections, as in the snow-bows. It is not unusual to see a fragment of the white bow near the horizon when there is a rainbow, the sun very low, and rain falling very heavily in the distance but within the observer's view, with a mist or spray rising near the ground from the heavy precipitation.

The variableness of the radius of the white bow, as measured by different observers may be found to result according to the distance of the observer from the fog producing the phenomenon, and the evidence of its causation by external reflections would appear to show that variation in the measurement of the radius would follow.

An example of the white bow, associated with the aureole and the shadow-mirage (Brocken Spectre), was observed for two hours from the top of the Blue Hill Observatory tower, near Boston, by moonlight on the night of August 6, 1911. An instructive

account of the phenomenon from Andrew H. Palmer appeared in *Science*, November 17, 1911, from which it appears that fog had been brought in from Boston Harbour by a light easterly wind, and reached to about the level of the upper window of the tower. Above the fog stratum, which had a distinct upper surface like a wavy sheet of water, and where the droplets were thin, the observer could see opposite to the moon, and at an apparent distance of 75 feet, an enlarged shadow of himself, surrounded by a white light (aureole), next to this latter a dark space and finally outside of all, the broad colourless circle or white bow with a radius of about 22°.

THE SHADOW-MIRAGE (BROCKEN SPECTRE). This phenomenon is usually seen near mountain summits, though in the instance just mentioned it was observed at a moderate altitude of about 700 feet above sea level, and by moonlight. (See Plate II, Fig. 2). It is sometimes observed with the shadows made by strong artificial lights.

In the enlarged images that sometimes occur with shadows, there is always mirage in addition to the reflection of the shadow itself from the fog. The view that this is mirage is held very widely and it is therefore advisable and appropriate to speak of the phenomenon as the shadow-mirage, since the average citizen of North America is not familiar with the Brocken hill of Saxony and the long association of the phenomenon with that summit of the Hartz Mountains. What, then, is mirage?

The County of Simcoe, with which I have been associated, is favourably situated for mirages of the Blue Mountain Ridge which runs along its western border. Mirages of this ridge are not uncommonly seen in the eastern parts of the county, thirty miles distant, and these may occur several times in a year. Throughout the plains of the western provinces also mirages are not uncommon phenomena. The universal quality of mountains generally on most days to look higher than they really are is also the effect of mirage. Almost daily, too, effects of mirage of the sun or the moon when rising or setting near the horizon, are to be seen in their enlargement, which is the chief effect of mirage.

In order to reach a proper understanding of the shadow-mirage it is necessary to supplement the usual explanation of a mirage

as due to layers in the air of varying densities by the assumption that the small droplets of water, acting as lenses, (in this class of mirage at least) afford the magnifying power that we see in the aggregate picture, as no layers of air of different densities exist on hilltops. Very small spheres of water are seldom absent from the air in summer time, even when no fog is to be seen, and these are necessarily a factor in producing magnified images. The magnifying power of droplets (when they are centrally acted upon) supplies an explanation of what the theory of layers has failed to explain or has failed to produce agreement.

The subject is comprehensible when it is assumed that the passage of light takes place through varying media instead of through series of similar ones, i.e., from air through droplets of water, not from air through air.

Multiple magnifying power of the kind produced by droplets is common in nature; the compound eyes of insects are multiple lenses and are commoner than the simple eyes of vertebrates. When we remember that there are half a million kinds of insects and one-tenth of that number of vertebrates, we can understand the extent of multiple sight. Nature has more ways of accomplishing the same result than our poor human philosophy and science can ever dream of. A mirage is seldom seen when the temperature of the air is below freezing point,—*i.e.*, when frost destroys the small spheres of water whose magnifying power produces the enlargement.

Blue Colour of the Sky. An ordinary non-achromatic lens, especially if of short focus, gives a blue-edged picture of any well-lighted view, especially when the picture is unfocussed. Accordingly, through the droplets of water, viewed near their centres, we get the soft blue haze of distant hills, so well expressed in the pleasing lines of the poet Campbell:—

> 'Tis distance lends enchantment to the view
> And robes the mountain in its azure hue.

The droplets also cause in the same way the blue colour of the sky, and the deep blue tint of the mirage. Although there are other ways of producing the blue colour of the sky, refraction and dispersion through the droplets are an effective cause. And as snow crystals have the same dispersive power as the fog droplets, viz.,

that of throwing off a blue edge with every lighted view, the result is the same both winter and summer. This dispersion at the blue edge of the spectrum by droplets and snow crystals complicates the work of the photographer. A distant view with its azure tints, as well as blue sky containing clouds, has to be "taken" very rapidly to get a well-defined picture, as the action of the blue light on the photographic plate, is very strong notwithstanding the distance of the objects themselves. It is advisable to know the cause of this in order to deal effectively with this peculiarity in photography.

The treatment of the blue colour of the sky in modern art is also deserving of a few passing remarks. In a memorial exhibition of paintings by the late Tom Thomson at Toronto in February, 1920, there was an instance of the modern artistic treatment of this subject. There was yellow-coloured sky, green-coloured sky, mauve-coloured sky,—every colour of sky, in fact, except blue sky; and this exhibition was typical of the prevalent treatment by others. If there is lack of appreciation of modern artistic efforts, the reason for it cannot be difficult to find.

Sunrise and Sunset Colours. When, instead of a highly lighted view, the lens with high dispersive power is directed toward a view in which there is a division into a dark part and a light part, with a clearly defined boundary between the two, the dark shadow or object showing through the lens, the red edge of the spectrum is then visible through one-half of the lens. Notwithstanding that the blue edge appears for the other half of the lens, it is thus possible to have the conditions in the first case for red illumination. There is only one time in the day, viz., when the sun is below the horizon, when this condition is possible, as the dividing line made by the horizon is then clearly defined. The floods of red colour at sunrise and at sunset are thus to be accounted for as the work of the droplets of water, this being the counterpart of the blue colour of the sky in daytime. When the view is more highly lighted by the risen sun, the blue dispersion soon preponderates over any red dispersion that may be present.

Owing to the earth in the morning being cooler than the air, (the reverse of the conditions in the evening) and the morning thus being the time for fogs and clouds, there are more red mornings

than red evenings. The "reds" are seldom seen when the sky is perfectly clear in very dry weather, but are abundant when clouds are numerous in damper weather, showing that the presence of water droplets is an essential condition for the formation of the red colour.

When the temperature of the air is below freezing and the droplets cannot exist, their place is taken by snow crystals, the colour-producing power of the atmosphere in the mornings and evenings being then carried on by the snow crystals as by the droplets in summer time, though less completely than in the latter instance.

Poets and literary people have waxed eloquent from the earliest times over the red colours of sunrise and sunset; artists have never grown tired of painting these scenes. For my own part I can gaze indefinitely at this intermediate stage between light and darkness, and find it always too brief. It is an emblem or simile of life itself, perhaps as old as language, not bursting suddenly into the full blaze of day or manhood, but coming up gradually through a growing intensity of colour; and again at the close of day, not suddenly extinguished, but gradually fading down through the glow of twilight into the dark.

With a little reflection it is easy to see that the colorations of blue and red that we have just described may be conceived as a huge horizontal corona, circling and covering the illuminated half of the great earth itself. As the earth revolves, this great corona passes over it daily. There are other red glows than those formed by the droplets, but this is the most effective cause.

Toronto, Ont.

TWENTY-SIXTH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

By Ralph E. De Lury

The success of the twenty-sixth meeting of the American Astronomical Society, held this year, August 30 to September 1, at Middletown, Conn., was in great part due to the care given to the arrangements by Professor Slocum and the authorities at Wesleyan University. Every convenience was provided for the eighty members and their friends who lodged in comfort in the college dormitories and dined in luxury at the Psi Upsilon fraternity house. The meetings were held in the well equipped lecture hall of the John Bell Scott Laboratory.

Nearly all had assembled by Monday evening, August 29th, many having come by motor car. After two sessions on the next day the guests were in the mood for the "hike" and motor ride, the latter developing into a semblance of a meteor shower, each car voting its orbit the most pleasant. In the evening the visitors enjoyed the hospitality of Professor and Mrs. Slocum at the Van Vleck Observatory, of which the fine equipment, library, general convenience and tidiness, were much admired. All were happy to learn that the twenty-inch lens would soon be ready for mounting. After the meetings on Wednesday a delightful excursion on the Connecticut River was arranged for the guests. The crew of the largest boat enjoyed a thrilling extra hour drifting about until rescued by a speed-boat from Middletown. After a ravenous attack on supper, "round-tables" discussed Cepheid variation and diurnal variation of clock rates,—opinion differing as to the nature of the variations but not as to the success of these informal discussions which are, indeed, one of the most valuable features of the meetings. On the final afternoon President and Mrs. Shanklin entertained at tea in their delightful home on the college grounds. In the evening the conversazione was held, at which several members displayed interesting exhibits, and at which fine lantern slides

were shown,—a feature being the excellent photographs of "dark" nebulae made by Duncan at Mount Wilson, two of which are produced here by kind permission (Plates III, IV).

The officers elected, re-elected or continuing to serve, are: President, 1919-1922, Frank Schlesinger; Vice-Presidents, 1920-1922, Otto Klotz; 1921-1923, John A. Miller; Secretary, 1921-1922, Joel Stebbins (re-elected); Treasurer, 1921-1922, Benjamin Boss (re-elected); Councillors, 1919-1922, Henry Norris Russell and V. M. Slipher; 1920-1923, Caroline E. Furness; 1921-1923, Philip Fox; 1921-1924, A. O. Leuschner and Frederick Slocum.

Sixteen members were elected to the Society bringing the total membership to 369.

Professor Carl Wilhelm Ludvig Charlier, of the University of Lund, was elected an honorary member of the Society.

The Eclipse Committee reported on various places where the total solar eclipse of September 21st, 1922, could be observed:

1. "*Maldive Islands*, Indian Ocean, Longitude 73° E., latitude 3° N. Duration of total phase, 4m 10s. Local true time 8h 16m, a.m. The sun's altitude 34°. This location is not attractive to American observers.

2. *Christmas Island*, Indian Ocean. Longitude 105° 40′ E., latitude 10° 25′ S. Duration 3m 40s. True time, 11h 50m, a.m., with sun 12° N. of zenith. The British Joint Eclipse Committee will send an expedition to the Island. It is not known that any American observers are planning to observe the eclipse from Christmas Island.

3. *Ninety Mile Beach*, north-west Australia. The central line of the shadow path enters the continent of Australia at the combined telegraph and post station of Wollal, longitude 120° 41′ E., latitude 19° 44′ S. Duration, 5m 18s. Local true time 1h 40m, p.m. Sun's altitude 58°. This region of Australia is excessively dry. The average rainfall for August, September and October does not exceed 0.06 inches monthly. The percentage of cloudiness is said to be very low and the winds light. The Lick Observatory definitely plans to dispatch a modest expedition to Wollal. The principal observations on the programme relate to the Einstein problem.

4. *Coongoola*, southern Queensland. Longitude 146° 0′ E.,

N

W

BRIGHT AND DARK NEBULAE SOUTH OF ZETA ORIONIS

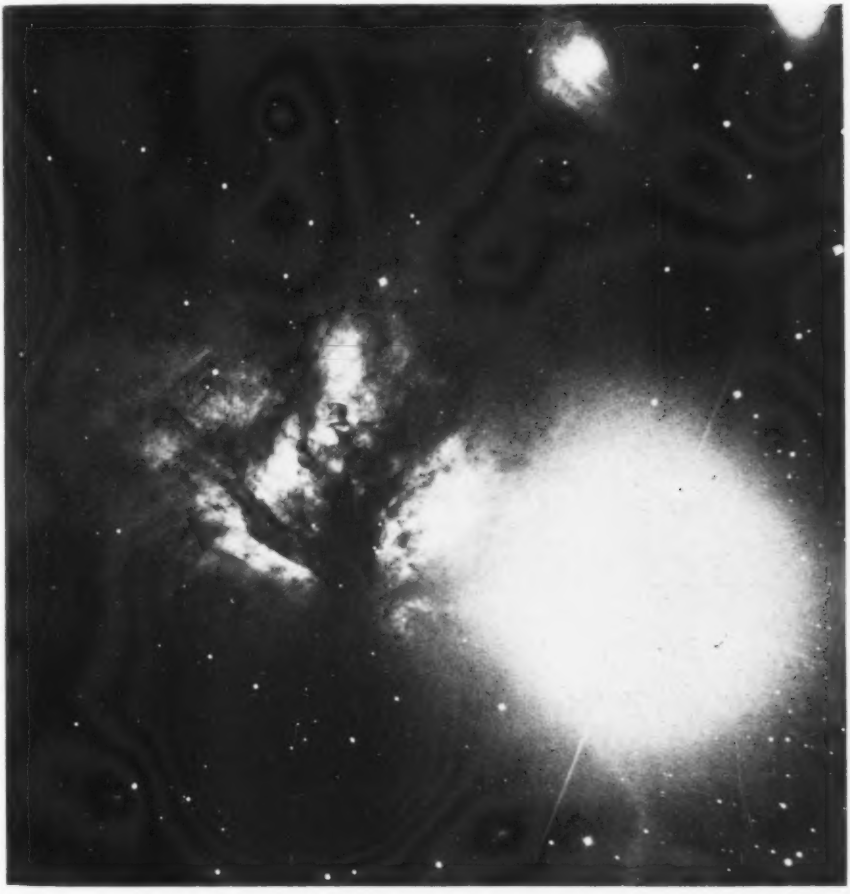
Scale: 1 mm. = 14″.0 (0.89 that of original negative)

Negative by J. C. Duncan with the 100-inch Hooker Telescope of the Mt. Wilson Observatory. The star Zeta Orionis is just beyond the north side of the plate. Note the remarkable dark cloud near the centre, forming a bay in the bright nebula.

(By courtesy of the Mt. Wilson Observatory and the *Astrophysical Journal*)

PLATE IV

N



W

ZETA ORIONIS AND THE NEBULAE ON THE EAST AND NORTH

Scale 1 mm. = 12".8 (0.81 that of the original negative)

Negative by J. C. Duncan with the 100-inch Hooker Telescope of the Mt. Wilson Observatory.

The bright star Zeta Orionis is near the west side of the plate, and irradiation has spread its light into a great blot.

(By courtesy of the Mt. Wilson Observatory and the *Astrophysical Journal*)

latitude 27° 45′ S. Duration 3m 45s. Local true time, 4h 1m, p.m. Sun's altitude 26°. The committee is unable to encourage the establishing of an observing station in this vicinity.

5. *Goondiwindi*, southern Queensland. Longitude 150° 20′ E, latitude 28° 30′ S. Duration 3m 30s. Local true time 4h 21m, p.m. Sun's altitude 21°. Conditions are favourable as to clear sky, but dust storms must be expected.

6. *Stanthorpe*, southern Queensland. Longitude 152° 0′ E., latitude 28° 40′ S. Duration 3m 25s. Local true time 4h 30m, p.m. Sun's altitude 19°. Altitude of railway station 2,600 feet.

7. *Casino*, southern Queensland. Longitude 153° 0′ E, latitude 28° 50′ S. Duration 3m 20s. Local true time 4h 34m, p.m. Sun's altitude 18°. The committee is unable to recommend that technical observers of the eclipse seriously consider a location in this region."

The Variable Star Committee reported on the variable star work and telescopes in America.

The Committee on Meteors also reported. (The report of the work of the American Meteor Society for 1914-1918 has appeared as Vol. II, Part 7, of the Publications of the Leander McCormick Observatory).

The complete reports, and abstracts of the papers presented at the meetings appear in Popular Astronomy. Titles of fifty papers were submitted, all but one of which were read. The subjects discussed may be noted under the following heads:

Sun and Solar System—Louis A. Bauer, "New measures of solar activity and the 'Earth effect'"; W. S. Eichelberger, "The mass of Neptune"; Ernest W. Brown, "A theory for the Trojan group of asteroids"; Julian L. Coolidge, "Gilbert's bombardment hypothesis"; H. H. Plaskett, "The intensity distribution in the solar spectrum"; E. C. Slipher, "Phenomena observed in connection with our transit of the plane of the rings of Saturn, 1921-1922"; Frank C. Jordan, "A remarkable meteor trail"; R. H. Curtiss, and B. B. McLaughlin, "The radial velocity and spectrum of comet 1913*f*"; G. E. Hale, "The probable absence of a measurable electric field in sun-spots"; Ralph E. DeLury and John L. O'Connor, "Displacements of lines in spectra of spots situated at various distances from the centre of the solar disc"; Ralph E. DeLury and Jean Edouard Bélanger, "Spectroscopic measure-

ments of the solar rotation in 1915"; G. H. Hamilton, "Mars in 1920".

Binaries, Orbits and Variables—S. I. Bailey, "Number and distribution of novae"; Zaccheus Daniel, "The parallax of Nova Aquilae, No. 3"; F. Henroteau, "The spectroscopic system Sigma Scorpii"; R. F. Sanford, "The orbits of three spectroscopic binaries"; J. S. Plaskett, "The spectroscopic orbit and dimensions of TV Cassiopeiae"; Alfred H. Joy, "The approximate orbit and absolute dimensions of S Antliae"; Reynold K. Young, (1) "Observations of 12 Lacertae, 1919, 1920, 1921"; (2) "Orbit of Boss 5442"; Frank C. Jordan, "Some remarks on Cepheid variables"; R. H. Curtiss, "The amplitude of variation of δ Cephei"; Antonia C. Maury, "(1) The orbit of ζ Centauri; (2) Preliminary note on υ Sagitarii"; P. W. Merrill, "Radial velocities of long period variables".

Star Positions and Proper Motions—F. W. Dyson, "Note on the parallaxes of stars with large proper motion"; E. S. Manson, Jr., "A computation of the solar motion from the radial velocities, proper motions, and spectroscopically determined parallaxes of 761 stars"; Benjamin Boss, "On the real motion of stars"; John A. Miller, "Parallaxes of 65 stars"; John H. Pitman, "Preliminary parallax of the Pleiades"; A. J. Roy, "Systematic corrections to right ascensions in star catalogues".

Nebulae and Star Clusters—John C. Duncan, "Dark Nebulae in the Orion and Sagittarius regions photographed with the Hooker telescope" (two of these photographs are reproduced in Plates III, IV); C. O. Lampland, "Notes on observations of nebulae"; A. van Maanen, "The internal motion in four spiral nebulae"; V. M. Slipher, "Further notes on spectrographic observations of nebulae and clusters".

Instruments and Mechanical Devices—George Henry Peters, "The new electric driving clock of the photographic telescope of the United States Naval Observatory"; Frank D. Urie, (1) "The Elgin Observatory"; (2) "Progress in chronographic registration of radio time-signals"; and (3) "San Diego radio time-signals"; Louis Bell, "The early evolution of the reflector"; Frank W. Very, "Solar hot-box studies".

Miscellaneous—J. S. Plaskett, W. E. Harper, Reynold K.

Young and H. H. Plaskett, "The radial velocities of 594 stars"; Harlan T. Stetson, "Some recent results of plate tests at the Harvard Astronomical Laboratory"; Edward S. King, "Some recent results in photographic photometry"; Frank E. Ross, "The relation between the diameter of a photographic star disc and stellar magnitude"; Frank C. Jordan and Keivin Burns, "On desensitizing plates in parallax work"; Sebastian Albrecht, "On the correlation of wave-length with spectral type and absolute magnitude"; Frank W. Very, "Atomic Structure"; Annie J. Cannon, "Peculiar spectra in the large Magellanic Cloud".

At the last session the members of the Society heartily adopted the following resolutions introduced by Dr. Klotz:

Resolved—That the American Astronomical Society herewith places on record its appreciation of the invitation extended by the President and Trustees of Wesleyan University to the Society for holding its annual meeting at Middletown, where the accommodation in every respect and for every want was so ample and commodious, leaving nothing to be desired.

To Professor and Mrs. Slocum and their able assistants, the Society expresses its gratitude for the assiduity and solicitude shown in making the whole stay at Wesleyan University such a memorable success.

The meetings of the Society have been so successful and well attended that it was decided to hold a meeting during the Christmas week, 1921. At the time of writing it is learned that the meeting is to be at Swarthmore. The place for the annual meeting in the summer of 1922 has not yet been decided.

THE UNIDENTIFIED BRIGHT OBJECT SEEN NEAR THE SUN

August 7, 1921

By J. A. Pearce

The object seen near the setting sun on the evening of August 7, by observers in both hemispheres has been the subject of much discussion and the following brief account of it may be of interest to the readers of the Journal.

On Sunday evening August 7, a party, which included Professor Henry Norris Russell, of Princeton, Major Chambers, Capt. Rickenbacher and Director Campbell, were observing the setting sun from the porch of the latter's residence upon Mt. Hamilton, Cal. Just at sunset (14h. 50m. G.M.T.) Major Chambers said: "What star is that to the left of the sun?" Capt. Rickenbacher said that he had been watching that star for several minutes but had not mentioned it because he supposed it was well known. All agreed that the body was star-like. Its appearance still seemed stellar when a minute later Director Campbell observed it through binoculars, not more than two seconds before it disappeared behind the cloud stratum at the horizon.

Upon consulting the *Nautical Almanac* it was evident that the object seen could not have been the planet Mercury, as was at first supposed. Professor Russell and Director Campbell concluded that it was brighter than Venus would have been under similar circumstances. After a comparison of notes the following telegram was sent to the Harvard College Observatory:—"Star-like object, certainly brighter than Venus, three degrees east, one degree south, of sun seen several minutes before and at sunset by naked eye. Five observers. Set behind low clouds. Unquestionably celestrial object. Chances favour nucleus bright comet, less probably nova." This information was distributed by telegraph the following day and is contained in H. C. O. *Bulletin* 757 of August 9.

The object was not seen again, although careful searches were subsequently made. The position assigned by Campbell was R. A. 9h. 22m., Decl. 15½° N; or in ecliptic coördinates, Long. 139°, Lat 0°.4 N. For his account of the observation see the October number of the *Publications of the Astronomical Society of the Pacific.*

Two observations were made in England on August 7. Lieut. F. C. Nelson Day and others at Ferndown, Dorset, saw the object at sunset (7h. G.M.T.), estimating its position as 4° from the sun and its magnitude as —2. Mr. S. Fellows observed it at Wolverhampton with binoculars shortly after sunset. He noted it as reddish, elongated towards the sun, which was distant 6°.

Astronomische Nachrichten No. 5118, contains an observation on this object made at Plauen, Vogtland, Lat. 50° 30′ N., Long. 12° 7′ E.; by the daughter of Professor E. Kaiser and several others. It appeared like Venus at its greatest brilliancy, low in the evening sky shortly after sunset. The time was 7h. 35m. G.M.T. Its azimuth was determined as 98° 27′.6 from south to west, and its apparent altitude as 2° 35′.9, or 2° 21′.9 when corrected for refraction. Professor Wolf, of Heidelberg, deduces that the R. A. was 11h. 6.7m. and Decl. was 7° 9′ N., or Long. 165°, Lat. 1° 20′N.

Nature, October 6, gives the following report:—"Dr. W. Bell Dawson of Ottawa, claims he saw a bright object low in the west in unusually clear air just before sunset on September 4, which he assumes to be the same as that observed at Mt. Hamilton, on August 7."

One other observation may be mentioned. Part of H. C. O. *Bulletin* 759 of October 14, is as follows:—"Dr. H. C. Emmert, of 3403 Warren Ave. West, Detroit, Michigan, states that he saw a bright object in the western sky on August 6, at 5h 50m E.S.T. Its altitude was 14°.5 to 15° and its azimuth 85°, the sun's altitude was 15°, and azimuth 90°. The object was fully as bright as Venus in twilight at her greatest brilliancy, and the light was perfectly steady." The date of August 6, was later confirmed by Dr. Emmert.

The writer plotted the above observations upon a celestial sphere from which the following deductions were drawn. The

positions of the planets on August 6, at 5h 50m p.m. E.S.T. were as follows:—Venus (—3.6) had just set; Mercury (—1.0) and Mars (+1.7) were too near the sun to be visible; Jupiter (—1.2) and Saturn (+1.4) were within 3° of each other in azimuth 55° and altitude 35°, the moon being in conjunction with each on that day. All planets were north of the ecliptic except Venus.

Dr. Emmert's observation was made in broad daylight two hours before sunset. The altitude and azimuth he assigned gives a position of Long. 139° and Lat. 8° S., the object being 11° from the sun. Clearly some discrepancy in his observation exists, for on that day when the sun's altitude was 15°, its azimuth was 99°; and when its azimuth was 90°, its altitude was 25°, and not 15°, as stated by Dr. Emmert. Moreover, there is the difference of one day to be accounted for.

It is very probable that Dr. Bell Dawson saw one of the planets which set soon after the sun on September 4. At sunset Mercury (−0.7) had an azimuth of 89° and an altitude of 4°; while Jupiter (−1.2) had an azimuth of 86° and an altitude of 6°, either of which would agree with his statement.

Miss Kaiser's observation was made one hour after sunset. According to the position given by Professor Wolf, its azimuth and altitude at sunset were 87° and 11°, respectively, which differs considerably from the observation made in England half an hour earlier, the azimuth of the sun when setting being 116°. It would be interesting to know more details concerning Miss Kaiser's observation as the position of the body is so accurately stated. It should be pointed out that Jupiter at the time of the observation had an altitude of 3°, and an azimuth of 93°, which is indeed very near the position assigned by her. It is therefore not unlikely that she observed Jupiter. otherwise it is difficult to account for the great difference between the position of her object and the position as stated by the English and Californian observers.

To account for the great motion along the ecliptic of 27° in 8 hours, if the Plauen and the Lick objects are to be assumed identical, the distance of the body from the earth on August 7, was, according to Professor Wolf, 0.005 astronomical units, or about twice the moon's distance. It appears unlikely that a comet at this distance would have had such a well-defined stellar appearance.

The English observations agree very closely with Russell's and Campbell's. Although the estimates of distances are probably too rough to be used for a deduction of motion, it would appear that during the interval of 8 hours the body had moved a degree or two closer to the sun.

What was it then, a nova or a comet? Being 40° from the Galactic plane would almost certainly rule out the former. A comet is more feasible. It may be noted that a comet with retrograde motion, near the plane of the ecliptic, and approaching the sun from behind might remain in close proximity to it the whole time it was bright. This was the case with the Tewfik comet of May 17, 1882. Although this hypothesis seems the most likely, the object still remains somewhat of a mystery.

NOTE:—On August 8, at 12h G.M.T., luminous bands were seen at Königstühl, (Heidelberg) and Sonneberg, and it was subsequently reported that the earth had passed through the tail of a comet on the night of August 7-8. *Astronomische Nachrichten* No. 5116 contains full particulars of the luminous bands seen and which now are believed to have been auroral.

Toronto, November 10.

ON THE ADJUSTMENT OF EQUATORIAL TELESCOPES*

By Howard Grubb

In submitting the following notes to the Liverpool Astronomical Society, I wish it to be distinctly understood that I do not claim any novelty whatsoever for any of the methods proposed. All books on astronomy give directions for adjusting telescopes, differing very widely one from another, and the amateur is sometimes puzzled as to the best method to adopt. I give in the adjoined notes the result of my own experience and the methods I myself have found best under various circumstances and conditions, and I shall be pleased if these notes prove at any time useful to Members of the Society.

An Equatorial Telescope that is in proper adjustment has its polar axis parallel to the axis of the earth, its declination axis at right angles to its polar axis, and the optical axis of the telescope at right angles to the declination axis. Also its circles are so placed that when the optical axis of the telescope is directed to the imaginary point of the heavens found by the intersection of the Equator and the Meridian, the declination circle will read exactly 0° if numbered for declination readings, or 90° if numbered for Polar distance readings, plus or minus a small quantity due to refraction, and the R.A. circle will read XXIV or XII according to whether the telescope is placed at E. or W. of pier.

In order that these conditions be fulfilled, certain adjustments are necessary after the instrument is roughly placed into position. The adjustments of the Equatorial are generally stated as follows:—

1. Adjustment of polar axis to the altitude of the Pole.
2. Adjustment of the zero point of declination circle.
3. Adjustment of polar axis to Meridian.

*This paper appeared in the *Journal of the Liverpool Astronomical Society* for October 1884. The instructions given by Sir Howard Grubb are believed to be of the greatest practical value to the amateur astromoner, and are reprinted at the suggestion of one who has recently tested their usefulness—Editor.

4. Adjustment of optical axis at right angles to declination axis.

5. Adjustment of polar and declination axes at right angles to each other.

6. Adjustment of the zero point of hour circle.

To these may be added, adjustment of optical axis of finder parallel to optical axis of telescope.

In making these adjustments it will be found necessary, as stated in all works on the subject, to repeat them several times, because the errors to some extent affect each other. It is desirable, therefore, to take the adjustments in such order as will render each, as far as possible, independent of those that follow.

In practice, therefore, I find this order best:—

1. Adjust finder parallel to telescope.
2. Adjust telescope at right angles to declination axis.
3. Adjust declination axis at right angles to polar axis.
4. Adjust zero of declination circle.
5. Adjust inclination of polar axis.
6. Adjust polar axis into Meridian.
7. Set zero of R.A. circle.

It will be seen as we go on that by a little care in the selection of objects, etc., each of these adjustments can be made almost independent of the errors of those following.

1. *To Adjust Optical Axis of Finder into Parallelism with the Optical Axis of Telescope.*—As all celestial objects are at great distances this is the same as saying that both telescope and finder should point exactly to the same object at same instant. To test this *crucially* it is necessary to define exactly the centre of the field of telescope. A pair of cross-lines in an eye-piece, or what is generally called a "Transit" eye-piece, is generally sufficient for this, but if a micrometer is to be used, and great exactitude is required, the micrometer may be placed in position and the centre found by rotating it (the micrometer) on its position circle and altering the position of the wires by the screw-head till the intersection of the position and distance wires (vertical and horizontal) appears to remain stationary on whatever object the telescope be pointed: probably a terrestrial object is best for this, as clockwork need not then be used. If now a star or other celestial object be

brought into centre of field of telescope, as defined by intersection of wires of micrometer, the same star should appear on cross-lines of finder on looking into it. If it is not so the finder needs adjustment. In small equatorials, and particularly when the tube is parallel, the finder is generally rigidly attached to main telescope, but the wire plate, *i.e.*, the metallic ring to which the cross-wires are attached, has four adjusting screws, two of which, if rightly placed, should be parallel to, and two at right angles to the line of declination axis, and these will allow of the ring carrying the whole set of cross-lines being adjusted a small quantity. These screws are generally made as "pulling" screws, *i.e.*, they pass through the tube and are tapped into the wire plate. Whatever side, therefore, the cross-wires require to be moved *from*, the screw at that side should be loosened and the opposite one tightened; care should be taken not to use too much force, for the screws act so powerfully on the ring that it is not an unfrequent occurrence to find the wires broken; the ring being forced out of shape by too much force on the pulling screws. If the adjustment required be too much for the wire plate, or that it is necessary to draw the cross-wires so much to one side as is decidedly apparent on looking through the eye-piece, it is better to make a rough adjustment by the finder supports, a slight slotting of the holes by which these are attached to tube; or a piece of card board under one or other generally brings the adjustment very nearly right, and avoids the necessity of placing the cross-wires sensibly eccentric in the field. In large instruments there is generally an adjustment in the supports themselves; sometimes both vertical and horizontal adjustments are on one support, but more generally the vertical adjustment is on one and the horizontal on the other; this is the plan usually adopted when the telescope tube is large and taper, for it is the more difficult to make the adjustment mechanically in the workshop in that case. This first adjustment is perfectly independent of any other, and I prefer to make it first for this reason, and also because it is convenient in making other adjustments to have a well adjusted finder to the telescope.

2. *To Adjust Optical Axis of Telescope at Right Angles to Declination Axis.*—As I consider that the reader will be much better able to make these several adjustments satisfactorily if he has an

intelligent appreciation of the *principles* on which he proceeds, I purpose explaining each as I go on.

For sake of simplicity, suppose it were possible to find a star exactly on the equator and in the meridian, and, moreover, that we could induce that star to remain apparently stationary during the time of our observation.

If now in figure 1 A B represents the axis of the telescope, and C D the declination axis, all looked at from direction of Pole. Suppose the telescope be pointed at this ideal star, it (the telescope) being at E. side of stand, and then that it be turned to other side of pier (W.), and again pointed to it as at A′ B′. If the telescope be exactly at right angles to declination axis, *i.e.*, if A D C and B D C be 90° then A′ D′ C and B′ D′ C will also be right angles, and the second position of telescope will be exactly parallel to the first. The instrument must, therefore, have been turned through exactly 180° on its polar axis; but if the telescope be not quite at right angles to declination axis, if, suppose the angle at A B C be greater than B D C, then it is evident that the whole instrument must be turned through more than 180° before the second position of telescope be made parallel to first, for if moved 180° only, the two positions would be as represented in figure 2.

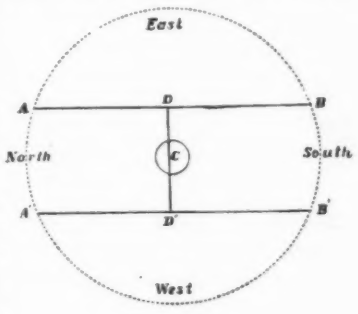


Fig. 1.

In practice we might take any star that happens to be *near* the meridian and equator, and as we cannot induce it to remain stationary we must allow for the difference of time between each observation.

So much for the *principle* of adjustment. *My usual practice* in making this adjustment is as follows:—

I choose any star that happens to be near the meridian and equator, and tolerably easily recognized, and I set telescope on this star (telescope being at E. side of pier) I start clock, and

with fine motion bring star to centre of field, where clock keeps it for a few minutes if in tolerable adjustment. At any definite time, preferably an even minute, by a clock or watch (an ordinary watch will answer for this observation) I stop equatorial clock, or disconnect it from driving circle, and then read R.A. circle and call this reading A. I now reverse telescope to W. of Pier, re-set on star, start clock, bring star to centre of field, and again at any other definite minute stop clock and read R.A. circle, and call this reading B. The difference between the readings of the R.A. circle should be equal to the difference of time shown by watch or clock, plus 12 hours.

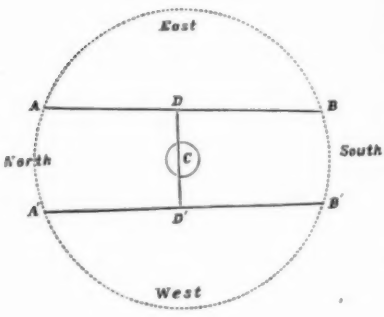


Fig. 2.

If the difference of readings of R.A. circle be in excess of the difference of time as shown by watch, plus 12 hours, the angle A D C, figure 1, is too great, and *vice versa*.

As Example		Time by Watch h. m. s.	R.A. Circle h. m. s.
A star is observed at	E. of pier at	8 5 0	3 7 16
"	W. "	8 10 0	15 12 45
	Difference	0 5 0	12 5 29
	Error.....		+29 sec.

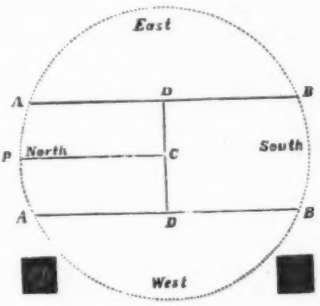
As this adjustment is supposed to be completed in the workshop there is generally no provision made in the mounting for effecting it, and it is very seldom required, but, if necessary, a liner of paper under one or other end of cradle will suffice. In the case above cited the liner should be placed under upper end of cradle, and if it be desired to find out about the thickness required, it may be done thus. Let S = number of seconds of time of error and L length of cradle in inches $\frac{15\ S\ L}{206265}$ = the thickness of paper required in parts of an inch.

Thus in above case, suppose cradle to be 10-in. long

$$\frac{15 \times 29 \times 10}{206265} = \tfrac{1}{4}\tfrac{1}{7}\text{th of an inch.}$$

The object of choosing a star on Meridian and Equator is to render this adjustment independent of others that follow after.

3. *To Adjust Declination Axis at Right Angles to Polar Axis.*—This is also an adjustment which is supposed to be left sufficiently perfect from the workshop, and for which provision is only made in the larger classes of instruments. The usual mode of adjustment recommended is to hang a level on some portion of the axis specially prepared for it, and then reversing, taking the readings of the R.A. circle in each case, the difference between which should be exactly = 180°. In high latitudes this plan answers well. As, however, but few modern equatorials are now supplied with levels to declination axis, I prefer to give here a mode of adjustment which can be adopted without this apparatus. My practice is to take a star near to the Pole and proceed to observe in the same way as per last (second) adjustment. If the second adjustment has been made correctly, any error found in this way must be an error between the declination and polar axis.



b Fig. 3. *a*

Suppose as before A B, Fig. 3, to be Telescope at E. of pier, and A′ B′, W. of pier; P C to be polar axis; C D declination axis, telescope E. of pier; C D′ declination axis, telescope W. of pier. Now if the angles A D C and B D C have been already adjusted to 90° by second adjustment as above, and that in observing Polar stars it is found that the two positions of telescope are not parallel when polar axis is turned through 180°, it is evident that the angle P C D is not a right angle.

(*Concluded in the January issue*).

MEETINGS OF THE SOCIETY

AT MONTREAL

October 27, 1921.—Between 50 and 60 members attended the meeting. Mr. A. W. Osgood, 138 Hutchison St., Montreal, and Mr. A. E. Mansfield, 107 Metcalfe St., Montreal, were elected members of the Society.

The President read a paper submitted by Geo. E. Forbes, one of our members (who was unable to be present), on the constellation "Andromeda". This related the legends of the ancients in connection with this constellation, and was particularly attractive from a literary point of view.

The event of the evening was a series of "Experiments on Light" by Prof. A. S. Eve, D.Sc., of McGill University. By a series of experiments, some of which were quite novel, Prof. Eve showed the reflection of light rays, and gave a short talk on them. The principles of the various types of telescopes were explained. He also showed the division of light rays through the prism into the colours of the spectrum. The measurement of the lengths of light waves was carefully explained, and the spectra of the gases helium and neon were shown.

The meeting concluded with the singing of the National Anthem.

H. E. MARKHAM, *Recorder.*

AT TORONTO

October 18, 1921.—The General Secretary gave a report of the Council meeting of October 14th. The American Association for the Advancement of Science will hold its Annual Meeting this year in Toronto, during the last week of December. It has been proposed that Section D, the Astronomical Section of the Association hold a joint meeting with the Royal Astronomical Society of Canada. The Council appointed a committee to attend to the details of the session. A committee was also appointed to urge the Dominion and Provincial Governments to increase their annual grants.

The Paper for the evening was given by Mr. A. F. Hunter, M.A., upon the subject "Rainbows, Fogbows, and their associated phenomena". The lecturer first explained the production of rainbows, showing by lantern slides how light in passing through the raindrops was refracted and dispersed, forming in each drop a continuous spectrum, which when reflected from the farther surface of the drops gave the pleasing phenomenon of the rainbow. The bow has a constant radius of 42 degrees. When there are two reflections within the drops a secondary bow is formed having a radius of 54 degrees and with its colours reversed. The dark space between the two red arcs is 12 degrees wide. When the drops are nearly all of one size the bows are particularly bright, and supernumerary ones are then formed by diffraction. Prof. Tyndall has produced by artificial means as many as eight within the primary bow, and five outside the secondary bow.

Mr. Hunter explained the peculiar circumstances attending the formation of excentric bows; horizontal bows; coronas around the sun and moon; the shadow mirages seen near mountain summits; and aureoles, those concentric prismatic rings, with the red edge inside which surround shadows upon dark backgrounds. Each type was illustrated by coloured slides.

In conclusion, Mr. Hunter explained the production of the beautiful rosy tints and hues of dawn and twilight whose intrinsic beauty charm not only the poet and artist, but every lover of nature. A short discussion followed the paper after which the meeting adjourned.

November 1, 1921.—The striking group of sunspots which were visible all last week and which showed great activity, was reported by Mr. Jackson and Mr. Miller. Mr. G. W. Bell described some observations on the interesting conjunctions of the planets, Venus, Jupiter and Saturn, on the mornings of October 22nd and 25th.

Dr. Chant exhibited a 3-inch altazimuth telescope recently made by the Consolidated Optical Company of Toronto. The optical parts of the instrument were of high quality, and the mechanical construction was of a superior kind. He also showed to the members a splendid reprint of Copernicus' famous "De Revolutionibus Orbium Caelestium", and Argelander's huge catalogue of 324,000 stars, which he completed in 1863. The observations were taken at Bonn with a 2¾ inch telescope mounted in the meridian. The 40 plates contain all the stars down to the 9th magnitude visible in that part of the sky from the north celestial pole to 1° south declination.

The paper for the evening was given by Mr. A. F. Miller, on "The Influence of Astronomy on the Science of Chemistry". The lecturer gave a most interesting exposition of the intimate relations between the pseudo-sciences of Astrology and Alchemy, which held sway for over 2,000 years, and which were so universally believed in that the illustrious Tycho Brahe, and even Newton were addicted to alchemical experiments.

Mr. Miller next traced the evolution of Spectroscopy through the 100 years of brilliant achievements from Wollaston to Hale. The classical experiments and discoveries of Wollaston, Fraunhofer, Herschel, Angstrom, Kirchhoff, Bunsen, and the more recent work of Huggins, Secchi, Janssen, and Lockyer were briefly described. A fitting tribute was paid to Fraunhofer, who died at the age of 39, and upon whose tomb is the epitaph, "He brought the stars near". Had he lived he would have undoubtedly anticipated many of the discoveries which were made during the 50 years after his death.

In conclusion, Mr. Miller referred to the great contribution of photography to present-day astronomy.

The Vice-President then called upon Mr. Hunter, who gave a brief account of the influence of Optics upon Astronomy. Mr. Hunter showed that with the invention of the telescope in 1608, astronomy became an accurate science. As the instrument became more perfected many discoveries, such as the velocity of light by Roemer, and aberration by Bradley, were made by it.

J. A. PEARCE, *Recorder.*

NOTES FROM THE METEOROLOGICAL SERVICE

Temperature—September 1921

The temperature was below the average from the British Columbian Coast to Saskatchewan and average and above from Manitoba to the Maritime Provinces. The positive departure was very marked in Ontario and varied from 4 to 7 degrees. The chief negative departure was in the Interior of British Columbia and was from 4 to 5 degrees. Departures from average elsewhere did not as a rule exceed 1 or 2 degrees.

Precipitation

The precipitation in British Columbia, although above the average over the greater portion of the Province, was below in some parts of the Southern Interior. In the Western Provinces it was below locally in portions of Alberta; elsewhere it was above the average to a very considerable amount, with local snowfalls in Alberta and Saskatchewan between the 9th and 12th. In Ontario it was below over the greater portion of the Peninsula and eastward to the boundary of the Province, whereas in more northern localities it was very much above the average. In Quebec it was above the average except in isolated localities. In the Maritime Provinces it was above in portions of New Brunswick and Prince Edward Island and much below in Nova Scotia. Some of the chief positive departures were: Swift Current, 2.80 inches; Battleford, 2.60 inches; Minnedosa, 2.90 inches; Winnipeg, 1.70 inches; Haileybury, 1.85 inches; Quebec City, 1.40 inches. Marked negative departures were: Edmonton, 0.80 inches; Parry Sound, 1.30 inches; Toronto, 1.60 inches; Ottawa, 1.10 inches; Yarmouth, 1.60 inches; Halifax, 2.20 inches; Sydney, 1.30 inches.

SEISMOLOGICAL NOTES, SEPTEMBER 1921

Victoria recorded twelve disturbances and Toronto ten during the month. Two were lost on the Toronto record due to stopping

of the driving clock. The most important of the series occurred on the 11th and 19th.

Victoria shows a trace amplitude of 4 mm. on the 11th, against 3.2 mm. at Toronto, but interpretation is difficult, due perhaps to the possibility of dual earthquakes. The origin appears to be very distant. At Toronto, the first tremor, probably a P wave, was recorded at 4h 21m 54s. (G.M.T.). The S came in at 4h 35m 16s, and the Maximum at 5h 55m 12s.

There were two quakes on the 19th, the second showing a trace amplitude of 1.5 mm. on the Victoria record with an origin 6860 km. distant. P waves were registered at 23h 30m 53s (G.M.T.), and the Maximum at 23h 58m 55s. The Toronto record gives an amplitude of 1.8 mm. J. Y.

Magnetic Disturbances—August, September, 1921

During the month of August the photographic records of the magnetic elements indicate a very quiet period at both Agincourt and Meanook.

During September a large disturbance was recorded on the 2nd. At Agincourt the beginning was gradual during the evening of the 1st, the movements became large and rapid about 23 o'clock, 75th M.T. and reached a maximum at 1.35 o'clock of the 2nd. The return to normal was very gradual during the morning. In D the disturbance caused a westerly movement of the needle amounting to 80′ west of normal. In H the force diminished 520γ below normal and the Z diminished 374γ below normal.

At Meanook the beginning was also gradual but rapid pulsations in D began about 20 o'clock (75th M.T.) and reached a first maximum at 1.50 o'clock (75th M.T.) of the 2nd, and a second maximum of still greater amplitude about 4.20 o'clock (75th M.T.). The E Declination during the earlier part of the disturbance was slightly diminished and during the latter part slightly increased.

Sun spots were not numerous during August and September. A fairly large group was central on the sun's disk on August 27th, and a large penumbral spot was central on September 19th, but from September 6th to 9th inclusive and on the 30th, no spots were visible.

The Aurora was visible generally over Canada during the first week of August, again during the last few days of August and the first week of September, and again from the 28th to 30th of September. It was of the 1st Class on the 1st and 28th of September.

W.E.W.J.

TEMPERATURES FOR MONTH OF SEPTEMBER 1921.

STATIONS	SEPTEMBER Highest	Lowest
Yukon		
Dawson	66	10
British Columbia		
Atlin	66	28
Agassiz	90	45
Barkerville	60	24
Kamloops	76	34
New Westminster	71	44
Prince Rupert	70	40
Vancouver	69	38
Victoria	68	44
West Provinces		
Battleford	78	31
Calgary	80	22
Edmonton	74	19
Medicine Hat	78	31
Minnedosa	80	22
Moosejaw	92	28
Oakbank	88	35
Portage la Prairie	98	34
Prince Albert	74	32
Qu'Appelle	85	29
Regina	80	27
Saskatoon	80	30
Souris	85	32
Swift Current	80	28
Winnipeg	91	36
Ontario		
Agincourt	92	41
Oak Ridges	89	42
Bancroft	89	29
Barrie	87	41
Beatrice	86	28
Bloomfield	89	40
Brantford	....	....
Chapleau	..	..
Chatham	94	43
Clinton	85	41
Collingwood	93	45
Cottam	88	40
Georgetown	88	41
Goderich	..	..
Gravenhurst	..	..
Grimsby	90	43
Guelph	87	38
Haliburton	89	30

STATIONS	SEPTEMBER Highest	Lowest
Ontario—cont.		
Huntsville	87	34
Kenora	81	37
Kinmount	..	..
Kingston	85	44
Kitchener	87	37
London	90	39
Lucknow	87	38
Markdale	..	..
North Gower	90	38
Oshawa	..	..
Ottawa	95	37
Paris	90	32
Parry Sound	89	40
Peterborough	89	36
Port Arthur	89	35
Port Burwell	79	41
Port Dover	86	42
Port Stanley	86	42
Queensborough	88	32
Ronville	86	34
Southampton	86	40
Stonecliffe	92	14
Stoney Creek	93	37
Toronto	92	34
Uxbridge	85	37
Wallaceburg	87	39
Welland	88	42
White River	87	26
Quebec		
Brome	86	32
Father Point	82	28
Montreal	86	46
Quebec	85	37
Sherbrooke	87	36
Maritime Provinces		
Charlottetown	85	37
Chatham	90	32
Fredericton	92	28
Halifax	..	..
Moncton	88	30
St. John	87	38
Sussex	86	25
Sydney	85	40
Yarmouth	77	38

ASTRONOMICAL NOTES

ONE HUNDRED YEARS OF CONTINUOUS PUBLICATION

The last number of *Astronomische Nachrichten* is a Jubilee number, commemorating the completion of a hundred years of publication, since the periodical was founded by Schumacher in 1821. The service that the *Nachrichten* has given to astronomy during these hundred years is incalculable. May its future progress and field of usefulness be as productive as in the past.

The current number, after an introduction by H. Kobold, opens with letters of greeting and congratulations from Professor S. S. Hough, H. M. Astronomer at The Cape, and one from former Director R. T. A. Innes of Johannesburg, S.A.

The following are the contents; they are given in full to show the wide range of subjects covered. Plates accompany the articles by Guthnick, See, Shapley and Hagen: H. Kobold, Geleitwort; S. S. Hough, Beglückwunschung; R. T. A. Innes, Beglückwunschung; G. Armelli, Sopra le perturbazioni secolari del pianetino Hungaria; E. E. Barnard, Observations of the companion of Sirius; O. Bergstrand, Uber die effektiven Wellenlängen der Milchstrassensterne; K. Bohlin, Bemerkungen zur Frage uber die Stellung der Spiralnebel im Raume; W. Doberck, Method of calculating double star orbits; A. Donner, Die Sterndichte in der photographischen Zone der Sternwarte Helsingfors; A. S. Eddington, The dynamical equilibrium of the stellar system; P. Guthnick, Einige Beobachtungstatsachen zum δ Cephei-Problem; J. G. Hagen, Dunkle Nebel und Sternleeren; A. Ivanoff, Kurzer Bericht über die Tätigkeit der Russischen Hauptsternwarte in Pulkowo für den Zeitraum von 1914 bis 1921; R. v. Kövesligethy, Ein astronomisches Gegenstück zur Seismologie; L. Krüger, Beziehungen zwischen dem alten und neuen Zentralpunkt der preussischen Vermessungen; F. Küstner, Die Parallaxe der Nova Persei 2 von 1901 und Örter von 79 schwachen Nachbarsternen nach Aufnahmen am Bonner photographischen 30 cm. Refraktor; Fr. Oom, La Croix du Sud et ses émules; C. D. Perrine, On systematic errors in the right ascensions of our present catalogues; T. J. J. See, The cause of temporary stars; H. Shapley, The galactic distribution of stars of spectral class B; E. Strömgren, Liberationen und periodische Ejektionsbahnen im allgemeinen Dreikörperproblem, nebst einem Beispiel periodischer Bahnen im Vierkörperproblem; A. A. Nijland, Bemerkungen zu dem Cepheiden-Problem; A. Wolfer, Die Sonnenfleckenhäufigkeit in den Jahren 1902-1920; H. v. Zeipel, Die Bestimmung der Massen der Sterne aus ihrer Verteilung in den Sternhaufen.

O. K.

FIGURES OF EQUILIBRIUM OF A ROTATING MASS

Sur les Surfaces de Poincaré by Pierre Humbert (*Journal de l'Ecole Polytechnique*, 2e serie, 20e cahier, Paris, 1920, pages 1-82).

Dr. Humbert gives the name of Poincaré's Surfaces to figures of equilibrium (which are very nearly Jacobian ellipsoids) of fluid rotating masses subjected only to the action of Newtonian forces; in other words to the various pear-shaped and cucumber-shaped figures which have been studied by Poincaré, G. H. Darwin and Liapounov. After a fairly long historical sketch concerning these surfaces and a study of the different systems of notation used by different authors, Dr. Humbert proceeds first to the computation of the semi-axes of the Jacobian ellipsoid at the point of bifurcation, just before becoming a Poincaré's Surface; the general method proposed by Liapounov is greatly simplified, on account of the fact that new and elegant forms have been introduced for the functions of Legendre and Lamé.

The following chapters are devoted to the geometrical study of the Poincaré's surfaces of the third and fourth orders whose elements have been computed respectively by Darwin and Liapounov. The first of these surfaces is the pear-shaped figure; Dr. Humbert shows that, contrary to Poincaré's idea, the sections of this surface have no points of inflection; he gives moreover several geometrical properties of these sections which allow their contours to be traced with great precision.

In the last chapters Dr. Humbert computes, for the first time, the elements of Poincaré's Surfaces of the fifth and sixth orders, giving the shapes of their sections through principal planes as well as several general geometrical properties of these surfaces.

F. H.

OBSERVATIONS OF VARIABLE STARS

Bulletin de l'Observatoire de Lyon, 1921. A great effort is being made in France to interest amateur astronomers in variable star observations. The *Bulletin de l'Observatoire de Lyon* is published by the Observatory of Lyons (Saint-Genis-Laval; Rhône, France). It gives lists of stars carefully selected for observation as well as valuable information concerning the different methods of observing them. It also publishes the results wherever the stars are observed.

On page 2 of its May number (1921) the Bulletin gives an account of the purposes of the French Association of variable star observers, membership in which is covered by the subscription to the Bulletin published monthly; the annual subscription is 12 francs or about $1.00 in Canadian currency, and it is the desire of the Association to extend its membership and collaborators over a wide area in as many countries as possible. It is scarcely necessary to say that Professor Jean Mascart is the energetic director of the Observatory at Lyons.

F. H.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

QUERY

I had two sun-shade glasses broken yesterday—my first experience of that kind—almost instantly when in focus. In one case I was using a "diagonal". The only reason I could imagine was that I was using a very low power, the lenses in the eyepiece being larger. Would that account for it?

My objective is $4\frac{3}{16}$ inches, clear aperture. I had always used direct vision, with powers 160, 180 and 252, on the sun for years, and never had a shade break. Of course I was careful to move the instrument at short intervals.—F. Kerr, Alexandria, Ont., October 28th, 1921.

ANSWER

A possible reason is that the eyepiece was in such a position that the light came to a focus upon the shade glass and, rapidly heating it at one place, caused it to crack.

A LAUDABLE PREVISION

The Dominion Government has secured some 63 acres additional land around the Dominion Astrophysical Observatory, Victoria, so that close encroachment on the observatory is provided against for all time.

Many European observatories are suffering to-day from the lack of prevision a hundred or more years ago.

WHAT YEARS HAVE THIRTEEN NEW MOONS?

A correspondent asks the above question, and the answer supplied to him may be of interest to the readers of the JOURNAL.

The course of time may be considered to be made up of cycles, each of 19 Civil years. A phase of the moon which happens on any date will recur exactly 19 years later. Thus there was a full moon on October 16th, 1921. There was a similar phase on October 16th, 1902, and there will be another on October 16th, 1940. This 19-year period is called the Lunar or Metonic Cycle. It was discovered by Meton, an Athenian astronomer, about 433 B.C.,

and so great fame did he thereby secure that it was ordered that on monuments to his memory his discovery should be recorded in letters of gold. The number which marks the place of any given year in the cycle is called its Golden Number. The cycle is so arranged that on the first day of the first year of the cycle the moon is new, or its age is 0 days.

Now 1900 was the first year of a cycle, 1919 was the first year of the following one, and so on; and as 1921 is the third year of the second-named cycle, its Golden Number is 3. The Golden Number for any year is the remainder obtained when 1 is added to the year number and the sum is divided by 19. Thus 1 plus 1921, *i.e.*, 1922, when divided by 19, gives a remainder of 3, the Golden Number for 1921.

The Epact is the age of the moon on January 1st, and according to what has been said the Epact is 0 on the first year of the cycle, or when the Golden Number is 1.

A Tropical or ordinary solar year contains 365.242 days, and a lunation, *i.e.*, the interval from new moon to new moon again, is 29.5306 days. Hence 12 lunations occupy 12 times 29.5306, or 354.367 days. Therefore the tropical year contains 12 lunations and 10.875 days over. We see, then, that, since at the beginning of the first year of a Lunar Cycle the age of the moon is 0 days, at the beginning of the second year the age will be 10.875 days; at the beginning of the third year, 21.750 days; of the fourth, 32.625 days, which is equivalent to 3.094 days; and so on.

Hence we have this rule: subtract 1 from the Golden Number, multiply the result by 10.875, and divide the product by 29.531; the remainder will be the Epact.

Approximately we may take the following rule: subtract 1 from the Golden Number, multiply by 11, and divide by 30; the remainder is the Epact. Sometimes this may be a day out.

Example: January 1st, 1921. The Golden Number is 3, the Epact is found to be 22; that is, on January 1st, the moon was 22 days old. Hence it will be new 8 days later, or on January 9th. Now 12 lunations will occupy 354 days, and so the moon will be new for the 13th time on December 29th. Hence we have the rule: there will always be 13 new moons if the Epact is greater than 19, *i.e.*, if the first new moon of the year occurs on or before January

11th. In the case of leap year the Epact must be greater than 20.

The years 1921, 1924, 1927, 1929, 1932, 1935, all contain 13 new moons: all years obtained by adding or subtracting 19 from these numbers will also contain 13 new moons.

THE MOON OUT OF ITS PATH

The recent report that the moon is some 12 miles ahead of its scheduled place has aroused great interest and has made some nervous people anxious about the future of our satellite. The following quotation from the London *Observer* gives some information upon this matter.

The phenomena of eclipses afford astronomers exceptionally favourable opportunities of correcting their estimates of the size and distance of the moon and its motion in its orbit, all of which enter into the determination in advance of the details of any eclipse.

During the recent lunar eclipse the position of the moon with reference to two stars that were occulted during its passage through the earth's shadow was very carefully measured at Greenwich Observatory, and it was found that our satellite's actual place in the sky was slightly in advance of the calculated place as tabulated in the *Nautical Almanac*.

This was what was expected, for observation of the moon during the last forty years has disclosed the fact that it has all the while been "running away from the tables".

The error of the moon's place is not great. It now amounts to about one-fifth of a minute of arc, which is, roughly, equivalent to one 150th part of its apparent diameter. But its existence constitutes an exceedingly difficult problem in gravitational astronomy, for after allowance is made for every known force that could affect the movement of the moon, it has been found impossible to identify the source of this disturbance.

The ablest mathematicians have devoted themselves to this problem, and many lunar theories have been devised which for a time seemed to harmonize the computed with the observed, or actual, places of the moon; but ultimately our satellite has confounded them all by obeying the mysterious unknown force accelerating its motion round the earth.

Some idea of the marvellous refinement of modern astronomical instruments can be gathered from the fact that the excessively small annual acceleration of the moon can be measured. The average value of the annual increase in the error in the last twenty years is approximately half a second of arc, or, in other words, about 800 yards at the moon's distance. Were the error remaining constant, the problem of tracing it to its source would be considerably simplified; but of late years it has been progressively increasing, and is now almost double what it was twenty years ago.

Dr. E. W. Brown, of Yale, one of our greatest authorities on the motion of the moon, is quoted in *The Times* (N.Y.), as saying:

> It has been known for forty or fifty years that the moon's motion did not perfectly follow the path calculated for it. It apparently gains a second of time and then gradually falls back again. The late Dr. Simon Newcomb studied observations of the moon over a period of 250 years and discovered that this unaccountable motion had taken place during the entire period.

One suggestion as to the cause is that the moon is a magnet, just as the earth and the sun are, and that the interactions of these magnets produces an observable effect on the moon. But such a magnetic effect has never been detected in the motion of any other heavenly body and this hypothesis is a pure speculation.

A 10-FOOT REFLECTOR PROMISED

In some of the newspapers of the Pacific Coast have appeared statements regarding a great observatory which is to be erected in Seattle, Wash., and which will contain a reflecting telescope ten feet in diameter, the mirror to be supplied by Mr. T. S. H. Shearmen, of Vancouver, B.C. In order to secure authoritative information the present writer asked Mr. Shearmen if he would prepare a statement for the JOURNAL and this he has promised to do. It will soon be forthcoming and in the meantime I am permitted to quote the following from a personal letter:

> Many years ago I devised a method of casting and annealing glass of any desired thickness and diameter and I have, therefore, not the slightest doubt regarding the successful outcome of the contract that I signed in May for the construction of a 10 ft. reflecting telescope. The donor of the observatory is Mr. Charles H. Frye, of Seattle. Mr. Frye has been a great collector of paintings and other works of art during recent years. Mr. Frye is now prepared to deal with the observatory plans that I have brought to his attention, in the same liberal manner.
>
> The great speculum will be completed in May, 1922, and then the plans for the observatory building will be considered. The tentative plans include a branch observatory in Hawaii or other tropical site. With a view to such work I spent six months in the Hawaiian Islands in 1914-1915. In the course of that investigation I found several ideal locations for a branch observatory.
>
> It brings back pleasant recollections to write a few lines for the Royal Astronomical Society of Canada, as I well remember meeting its early members and founders, such as the late Mr. Carpmael, Mr. Elvins, Mr. A. F. Miller, and others.

Mr. Shearmen at one time gave instruction in astronomy in Woodstock College and later lived in Brantford, Ont. We hope he may be successful in his great task.

ARE WE TO HAVE A NEW CALENDAR?

There have been many proposals made to reform the ridiculous arrangement of days, weeks and months which we call our Calendar, almost every one being an evident improvement on our present arrangement; but nothing has ever come from them. The fixing of the date of Easter and the other movable feasts has always aroused opposition from some of the ecclesiastical authorities and no considerable change could ever be made without substantial agreement among a large number of nations.

But it looks now as if a change is coming. Next April a meeting of the International Astronomical Union is to be held in Rome, and one of its sections deals with the Calendar. However, little result will follow from its deliberations were it not for action which has been taken by the Roman Catholic Church. The Vatican will call a conference of astronomers in April to consider the Calendar, and Cardinal Mercier is to preside over the meeting.

The main purpose of the conference is to reform the existing Gregorian Calendar on a scientific basis which shall make the same dates fall on the same week-days and the date of Easter always be the same.

A promising method of reforming the Calendar is to consider the year proper to be 364 days. This would be divided into 4 quarters each of 91 days, each quarter to have two months of 30 days and one of 31 days. The odd day would be a holiday, perhaps New Year's Day. In leap year there would be an extra day intercalated between June and July,—a pleasant time of the year. January 1st, April 1st, July 1st, and October 1st, the first day of each quarter, would be on Monday. Christmas would always fall on Monday. Easter Sunday would be fixed to April 14th, and the other church festivals would always be associated with the same day of the year. November 11th, Armistice Day, would be on Sunday.

The Vatican, it is said, will probably invite the Anglican Church and the Greek Church to be represented at the Conference and it seems very likely that the reform will come.

Among the various schemes for reform which have been presented may be mentioned one by Dr. A. D. Watson, which is outlined in the *Transactions* of the Astronomical and Physical Society of Toronto for 1896. He proposed 13 months, each of 4 weeks, so that the days of all the months would be identical in arrangement. This is certainly simple and scientific but would demand greater change than that just outlined.

EARTH HAS 14 MOVEMENTS

In some of our newspapers there has appeared the following statement, attributed to Camille Flammarion in the Paris *Temps* giving the earth's fourteen motions:

Daily rotation, annual revolution, fluctuation or rocking due to the precession of the equinoxes in a period of 26,765 years, monthly movement of the earth around the centre of gravity of the "earth-moon couple"; nutation caused by the attraction of the moon every eighteen and a half years; variations, coming once every century of the obliquity of the ecliptic; variations every century of the eccentricity of the terrestrial orbit, displacement of the line of apses every 21,000 years; disturbances caused by the constantly changing attraction of the planets; displacement of the centre of gravity of the solar system around which the earth travels annually, this centre being determined by the variable positions of the planets; perpetual variation of latitudes; daily tides of the continental soil; displacement of the whole Milky Way, of which our sun is one star, toward the constellation of Capricorn, at the formidable speed of 375 miles per second, or 1,250,000 miles per hour.

M. Flammarion of course knew just what he was writing about, but many of his readers have been somewhat misled. In the first five chapters of his "Popular Astronomy" he discusses the *eleven* motions of the earth, but here the number is given as *fourteen*, as though 3 new ones had been added since the book was written. As a matter of fact, it is impossible to analyse the motion of the earth into any specific number of components. It has two great motions, namely, the daily rotation and the annual revolution, and the uniformity of these is disturbed in many ways; but a wrong impression is given when we look on these disturbances as distinct separate motions. The motion of the solar system through our stellar universe, and of the universe itself towards some external point may be added to the above two motions, though the latter is somewhat conjectural as yet.

C. A. C.

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